Investigation Report
Gasoline on TK38 External Floating Roof

EPA Region 10
Deemed Releasable

JULIE VERGERONT
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Date: 2023.01.28 08:41:29 -08'00'

Date & Time the Incident Began: 12/16/10 12:00 PM
Investigation Start Date & Time: 03/14/11
Report Date: 04/07/11
Investigation Team Members: Alan McIntyre

Incident Summary:

On 12/16/10 at approximately 12:00 PM, an estimated volume of 4,000 bbls of gasoline was discovered on the external floating roof of TK38. The incident was classified as an LOPC, but did not result in an environmental exceedance. No injuries or equipment damage resulted from this incident, but the potential existed for both. TK38 mixers were shut off and the area around TK38 was barricaded off to traffic. Firefighting equipment was staged in the area as a precaution. A benzene regulated area was established around the tank.

TK38 was emptied and the gasoline was removed from the roof for inspection. Roof inspection took place on 12/22/10 and found no damage or leaks in the roof deck, pontoons, drain line, or roof seals. Thus, TK38 was deemed fit for service and was next filled with a gasoline blend on 1/1/2011.

Situation Description:

Incident Description

On December 16, 2010, TK38 was filled with finished gasoline (blend #1061). The blend was completed at 10:50 a.m. at which time TK38 level was 50.8 feet. Shortly thereafter, an RP&S Operator on Special Assignment was driving past TK38 and noticed that the roof drain line was just barely dripping. When the Operator reached the corner of 9th and B Street, he noticed a very strong gasoline odor. The Operator immediately shut down his truck and started walking back toward TK38. As the Operator got closer to TK38, he could no longer detect the gasoline odor. The Operator continued around the base of TK38 looking for any signs of a leak. The Operator then climbed the stairs to the TK38 gauger platform and observed gasoline and water on top of the external floating roof. The rolling ladder track near the middle of the roof was completely submerged (8 – 10” liquid depth), but not totally submerged toward the edge of the roof. The liquid was within about 5-6 feet of the inner edge of the annual pontoons all the way around the roof circumference. The emergency overflow drain near the center of the roof was not submerged (liquid was about 2” below the inlet to the emergency overflow drain).

The initial thought was that the internal roof drain line had developed a leak allowing gasoline to backflow through the drain line and check valve to the roof. TK38 has a Pivot Master floating roof drain system. See Figure 1.

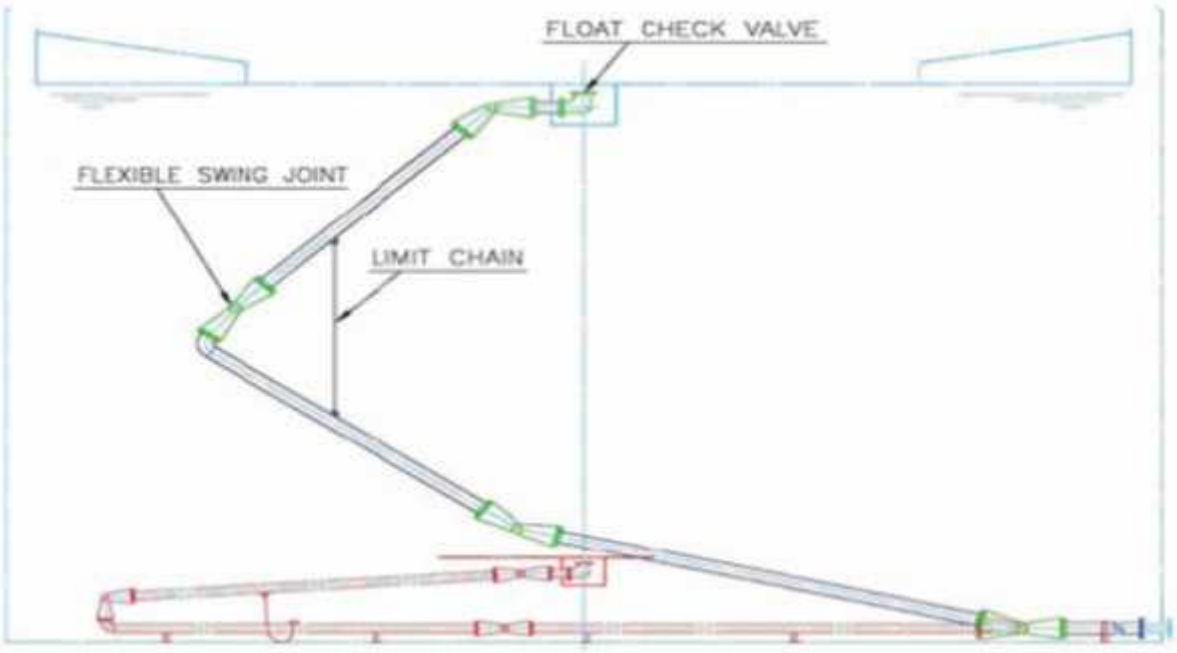

Figure 1: Typical Pivot Master Drain System

In order to test the leaking roof drain line theory, the Check Mate Hydrocarbon Sensing Valve on the drain line discharge was isolated and removed by maintenance. The Check Mate Hydrocarbon Sensing Valve is basically a check valve designed to be normally open to allow water to flow through the valve, yet close in the presence of hydrocarbon products. This is accomplished via a hydrocarbon sensing element (Styrofoam). The hydrocarbon sensing element will dissolve in the presence of hydrocarbon causing a check valve to close and stop flow. See Figures 2, 3, and 4.

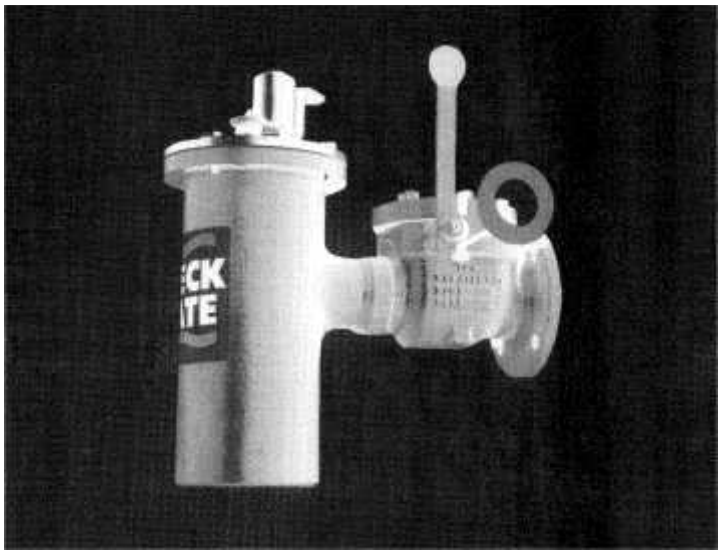

Figure 2: Check Mate Hydrocarbon Sensing Valve Picture

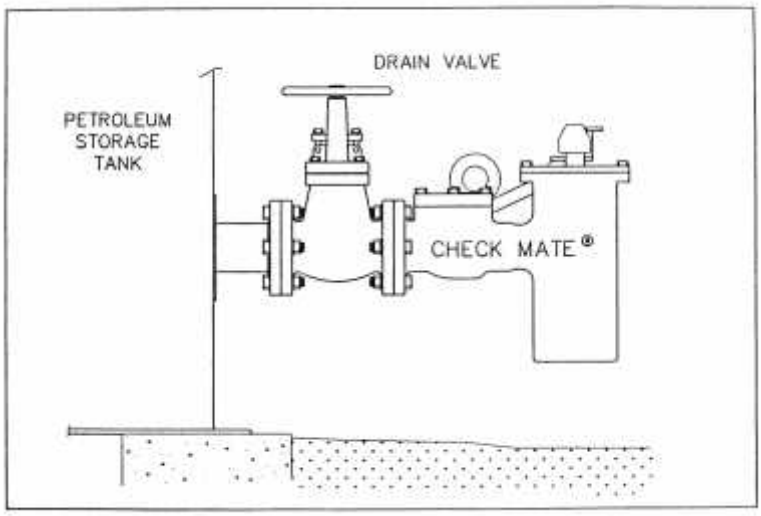

Figure 3: Check Mate Hydrocarbon Sensing Valve Outline

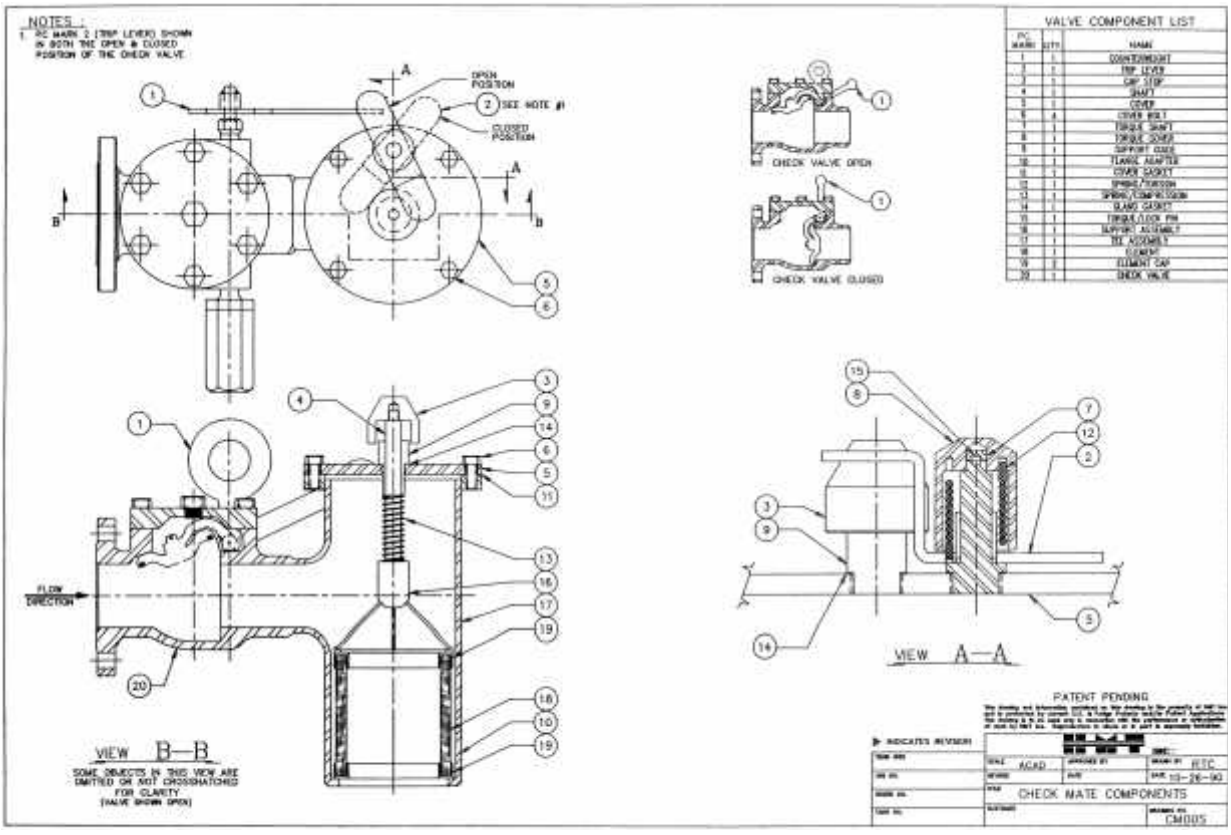

Figure 4: Check Mate Hydrocarbon Sensing Valve Details

Once the Check Mate Hydrocarbon Sensing Valve was removed, Operations opened the block valve on the roof drain line nozzle and no liquid flowed out. This proved that hydrocarbon was not leaking into the internal roof drain line and in fact demonstrated that the roof drain line was obstructed.

The hydrocarbon sensing element in the Check Mate valve was found to be coated with green algae. The flange face and check valve seating surface were also found to be corroded beyond repair.

At 3:20 p.m. on December 16th, RP&S Operations began emptying TK38 by pumping it to a vessel at the dock (the Chinook Maiden) and then the remainder to TK50.

By the morning of December 17th, additional liquid was observed on TK38 roof (no rain overnight) and the level on the roof was still increasing as the tank continued to be emptied. The highest level noted was about 4" below the inner edge of the annual pontoons and the emergency overflow drain was submerged.

Initial emptying of TK38 was completed on December 17th at 10:00 a.m. The level in TK38 was now 6.6 feet.

Maintenance then attempted to clear the TK38 roof drain line by hooking up a vacuum truck to the drain line outlet nozzle and pulling a vacuum on the line. Initial attempts of slowly pulling a vacuum on the drain line were not successful in clearing the obstruction. The block valve on the drain line outlet nozzle was then closed and the vacuum truck was allowed to develop a deep vacuum. The drain line outlet block valve was then opened causing a rapid vacuum to be pulled on the drain line. After several quick "pops" the obstruction was cleared and the drain line began flowing.

Once the drain line was cleared, the vacuum truck was disconnected and RP&S Operations began draining water from the roof to the sewer. Upon emptying the vacuum truck, a "green slime ball" (algae/moss) was discovered.

Water was drained from TK38 roof for nearly 7 hours (December 17th 3:45 p.m. to 10:36 p.m.) before the gasoline layer was reached.

A field pump was then hooked up to the TK38 roof drain line and the gasoline on the roof was begun to be pumped to TK36.

On December 18th from 9:00 a.m. to 1:25 p.m., the remainder of the gasoline inventory in TK38 was transferred to TK50 in order to land the roof of TK38. The level in TK38 was now < 4.2 feet.

On December 19th at 10:30 a.m., the TK38 roof drain line became obstructed again and the transfer of the gasoline on TK38 roof to TK36 was stopped. The drain line was again cleared on December 20th using a vacuum truck. RP&S Operations then drained a small amount of water from TK38 roof to the sewer (it had rained slightly the previous

two days) and then resumed pumping gasoline from TK38 roof to TK36. The removal of gasoline from TK38 roof was completed on December 21st at approximately 9:00 a.m. On December 21st, TK38 roof was refloated at 11:00 a.m. by transferring 900 bbls of gasoline back from TK36 to TK38. TK38 level was now 4.5 feet. An additional 5,500 bbls of gasoline was transferred back from TK36 to TK38 on December 22nd at 12:55 a.m. to raise TK38 level to 6.5 feet.

On December 22nd, PEI was given access to inspect TK38 roof. Inspection revealed no damage or leaks in the roof deck, pontoons, or tank seals that would allow gasoline to get on the roof.

On December 22nd, Maintenance cleaned out the TK38 roof drain sump and verified that the roof drain check valve was clear and functioning properly. Several buckets of dirt/slime/moss were removed from the sump.

TK38 roof was monitored for closely for several days and no liquid on the roof was observed. Thus, TK38 was deemed fit for service and was next filled with a gasoline blend on January 1, 2011. TK38 roof has been functioning normally since this time.

TK38 History

TK38 was designed by Morse Construction Group and was constructed in 1991. TK38 is 140 feet diameter by 60 feet 6 inches height (153,000 bbl capacity). TK38 roof is a single deck annular pontoon external floating roof.

See figure 5 for a cutaway view of a typical single deck annular pontoon external floating roof tank.

TK38 has a 24” diameter by 12” deep sump in the center of the roof to collect rain water. There is a 4” diameter horizontal nozzle on the sump wall centered 6-1/2” above the sump floor. A check valve is installed on this nozzle in the sump to prevent backflow. A pivot master drain internal drain system is connected to the 4” nozzle on the inside of the tank to allow rain water to drain to a nozzle on the shell of the tank at grade.

TK38 also has a 6” diameter emergency overflow drain nozzle on the roof. This is a vertical nozzle through the roof deck located 5 feet from the center of the roof. This nozzle extends 12” above and 12” below the roof deck. A 10” diameter wire mesh screen with a top cover sits on top of the nozzle.

According to PEI, the liquid level was observed to be about 4” below the inlet to the emergency overflow drain line after all the liquid was removed from TK38 roof.

See figure 6 for a cross-sectional view of TK38 roof.

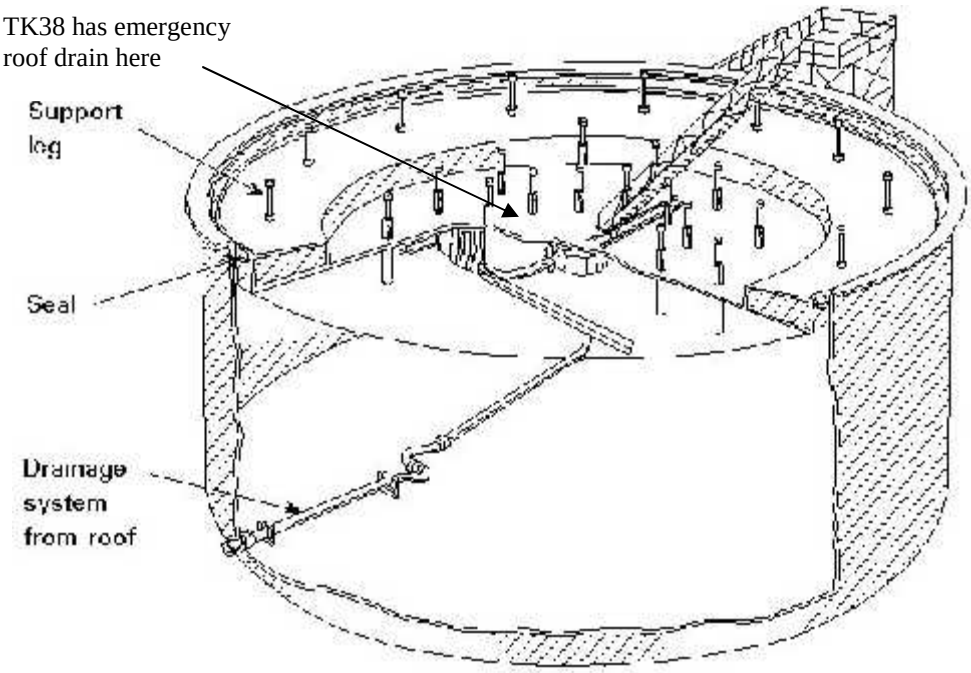

Figure 5: Annular Pontoon Single Deck EFR Tank

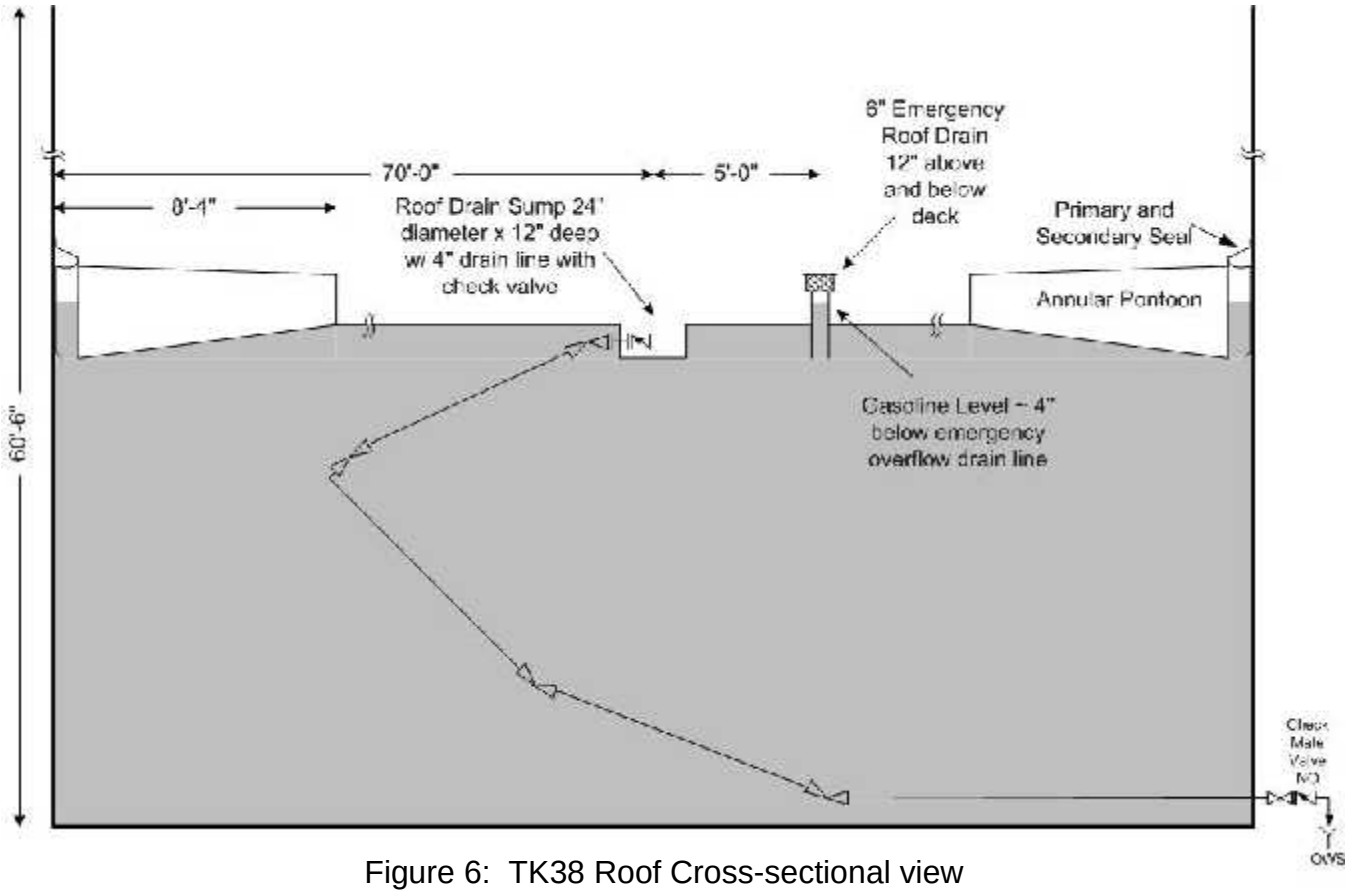

Figure 6: TK38 Roof Cross-sectional view

Problem Statement:

Expected: Product is contained within the tank and stays within the tank.

Actual: 4,000 bbls of gasoline was sitting on top of TK38 floating roof.

Impact: LOPC

Sequence of Events Leading up to the Incident:

Approximately one to two weeks prior to the incident (Nov 28th – Dec 10th), an RP&S Operator working day shift noted that TK38 roof drain did not seem to be flowing as much as other tanks. It had rained the night before. The Operator then climbed the stairs to the TK38 gauger platform and observed some water on TK38 roof. The water covered a pie-shaped area from the center of the tank to the south-west side, where the rolling ladder is. The water was within about 6 inches of the inner edge of the pontoons on the south-west side of the tank. The Operator observed the emergency overflow drain line sticking up above the water level and believed this was the roof drain. The Operator concluded that TK38 roof drain design must be different from other tanks and so the amount of water observed was not abnormal.

On December 12th day shift, a different RP&S Operator was on TK38 gauger platform to gauge the tank. This Operator also noticed some water on TK38 roof and communicated his observation over the radio. The Operator who had previously observed the water on TK38 roof was also on shift and asked the Operator to describe the shape of the water covering TK38 roof. The description matched the earlier observation and so the Operator was informed that this was not abnormal.

Note that RP&S Operators were also on the TK38 gauger platform on Dec 2nd, 7th, 9th, and 13th and did not report anomalies. However, three of these instances were on night shift with limited visibility.

Refer to table 1 for a summary timeline of the incident.

Table 1: Incident Summary Timeline

Date/Time	Event
Sometime Between 11/28 - 12/10	Operator observes water on TK38 roof. Believes this is normal due to roof drain design.
11/28 12:00 AM - 11:59 PM	0.18 inches rain
11/29 12:00 AM - 11:59 PM	0.03 inches rain
11/30 12:00 AM - 11:59 PM	0.22 inches rain
12/1 12:00 AM - 11:59 PM	0.01 inches rain
12/2 Day Shift	Operator sampled TK38. TK38 level was 36.8 ft.
12/7 12:00 AM - 11:59 PM	0.04 inches rain
12/7 Night Shift	Operator sampled TK38. Does not recall seeing water on roof. TK38 level was 9.5 ft.
12/8 12:00 AM - 11:59 PM	0.56 inches rain

12/9 12:00 AM - 11:59 PM	0.24 inches rain
12/9 Night Shift	Operator sampled TK38. Does not recall seeing water on roof. TK38 level was 24.3 ft.
12/10 12:00 AM - 11:59 PM	0.10 inches rain
12/11 12:00 AM - 11:59 PM	0.71 inches rain
12/12 12:00 AM - 11:59 PM	1.46 inches rain
12/12 Day Shift	Operator observes water on TK38 roof when gauging of tank. TK38 level was at 8.1 ft. Operator radios observation and is told it is normal to have some water on TK38 roof.
12/12 4:50 PM - 7:05 PM	Dock line displacement (6,000 bbls) to TK38. TK38 level now 10.3 ft.
12/13 12:00 AM - 11:59 PM	0.11 inches rain
12/13 8:00 AM - 3:25 PM	Transferred 20,000 bbls from TK21 to TK38. TK38 level now 17.6 ft.
12/13 Night Shift	Operator sampled TK38.
12/14 12:00 AM - 11:59 PM	0.08 inches rain
12/15 12:00 AM - 11:59 PM	0.02 inches rain
12/15 9:10 PM - 12/16 10:50 AM	Blend #1061 to TK38. Peak fill rate during blend was 7,400 bph, which is below the historical maximum fill rate. TK38 level now 50.9 ft.
12/16 ~12:00 PM	Operator driving by TK38 detects strong gasoline odor. Shuts of truck and begins investigating. Finds Gasoline on TK38 roof.
12/16 3:20 PM - 12/17 10:00 AM	TK38 transferred to vessel at dock (Chinook Maiden) then to TK50. TK38 level now 6.6 ft.
12/17 ~7:00 AM	Additional liquid was observed on TK38 roof (no rain overnight) and the level on the roof was still increasing as the tank continued to be emptied. The highest level noted was about 4” below the inner edge of the annual pontoons and the emergency overflow drain was submerged
12/17 ~3:00 PM	Vacuum truck connected to TK38 drain line and was able to get the roof drain flowing.
12/17 3:45 PM - 10:36 PM	Drained water off TK38 roof to sewer.
12/17 ~11:00 PM	Hooked up field pump and started pumping gasoline off TK38 roof to TK36.
12/18 12:00 AM - 11:59 PM	0.03 inches rain
12/18 9:00 AM - 1:25 PM	Finished transfer of TK38 to TK50. TK38 roof now landed, level <4.2 ft.
12/19 12:00 AM - 11:59 PM	0.01 inches rain
12/19 10:30 AM	TK38 roof drain plugged up.

12/20 Day Shift	Vacuum truck connected to TK38 drain line and was able to get the roof drain flowing. Drained small amount of water from TK38 roof to sewer and then resumed pumping gasoline from TK38 roof to TK36.
12/21 ~9:00 AM	Finished pumping gasoline from TK38 roof to TK36.
12/21 10:00 AM - 11:00 AM	Transferred 900 bbls from TK36 back to TK38 to refloat TK38 roof. TK38 level now 4.5 ft.
12/21 11:15 PM - 12/22 12:55 AM	Transferred 5,500 bbls from TK36 back to TK38. TK38 level now 6.5 ft.
12/22 Day Shift	PEI inspected TK38 roof. No damage found that would account for hydrocarbon getting on roof (no leaks in deck, pontoons, or internal drain line. seals good).
12/22 Day Shift	Maintenance cleaned out TK38 roof drain sump and verified check valve functioning properly. Several buckets of dirt/slime/moss were removed from the sump. The check valve was functioning propertly and was not removed.

Cause Analysis:

The cause of this incident was the accumulation of rain water on TK38 which added weight to the roof causing it to flex in the center and sink lower into the gasoline volume within the tank and force gasoline onto the roof through the emergency overflow drain line. Refer to Figure 7.

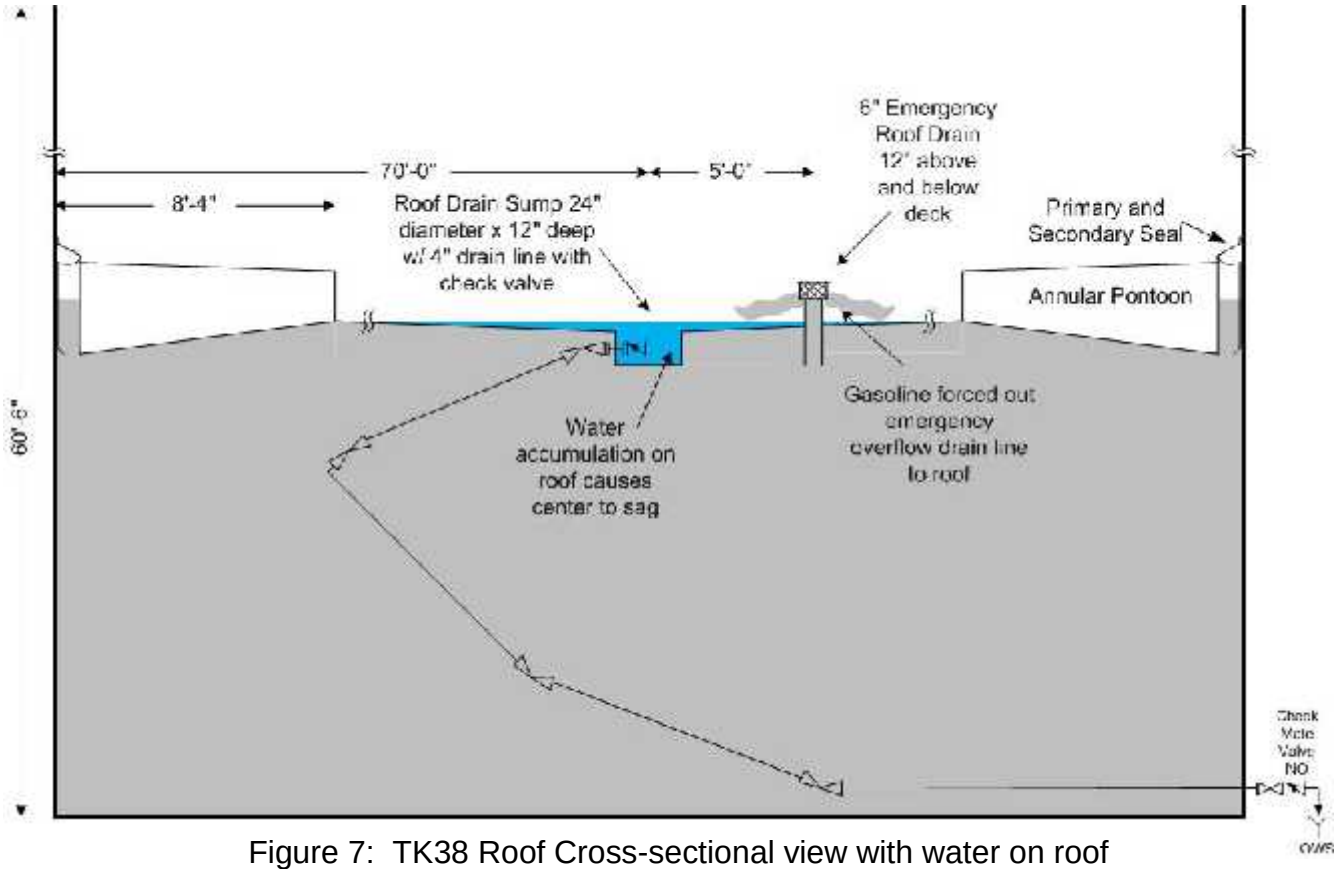

Figure 7: TK38 Roof Cross-sectional view with water on roof

The cause of the rain water accumulating on the roof was due to an obstructed roof drain line. The nature of the obstruction could not be positively determined, but is believed to be due to either accumulation of debris (sediment/moss/algae) in the roof drain sump or due to a sticking roof drain check valve. Given the amount debris removed from the drain line with the vacuum truck and the subsequent amount of debris removed by hand, it is likely that this was the most probable cause. The inspection of the check valve revealed no operational problems.

The exact time that the gasoline flowed onto TK38 roof could not be definitively determined. No gasoline was on TK38 roof on December 13th night shift, which was the last time prior to the incident that an RP&S Operator was on TK38 gauger platform. TK38 level was 17.6 feet at that time. Additional rain fell on December 14th and 15th (0.10 inches total). The most probable time that gasoline flowed onto TK38 roof was during the filling of TK38 with finished gasoline blend #1061 from Dec 15th 9:10 p.m. to December 16th 10:50 a.m. It is likely that the gasoline level in TK38 was very close to the emergency overflow drain inlet prior to filling TK38 due to the accumulation of rain water on the roof. The dynamics of filling TK38 likely forced some gasoline onto TK38 roof through the emergency overflow drain. TK38 was filled at a peak rate of 7,400 bbl/hr during blend #1061. This is below historical maximum fill rates for TK38. During tank filling it is not unusual for a roof to sometimes get momentarily hung up as it rises. This would cause further flexing in the middle and allow gasoline to flow through the emergency overflow drain if the level in the tank was already very close to the emergency overflow drain inlet.

Similarly, during the emptying of TK38 from December 16th 3:20 p.m. to December 17th 10:00 a.m., it is likely that the roof also flexed more in the center. This would account for the observation that additional liquid was found on TK38 roof on the morning of December 17th.

Emergency Overflow Drain Contributing Factor

TK38 is one of only a few tanks at PSR, which has an emergency overflow drain on the roof. Other tanks include TK39, TK45, TK72, and TK73 (this is not a comprehensive list, there may be others). All of these tanks were designed by Morse Construction Group.

The emergency overflow drain on TK38 roof was assumed by some Operators to be the primary roof drain and misled them to believe TK38 roof would always have some water level due to the design.

The emergency overflow drain line also provided the route for gasoline to flow onto TK38 roof.

API Standard 650 (Welded Steel Tanks for Oil Storage – Eleventh Edition, June 2007) now prohibits emergency overflow drains on single deck pontoon roofs for new tank construction or repairs to existing tanks. This is because the product level in the tank is always higher than the rain water level in the center of the deck, which would cause the product to discharge through the drain onto the roof rather than allow rain water to drain into the tank. Note: PEI follows API 653 (Tank Inspection, Repair, Alteration, and Reconstruction) for inspection and repair standards. If repairs are required, this standard refers back to API 650.

Conclusions:

The accumulation of rain water on TK38 roof due to an obstructed roof drain line in combination with the presence of an emergency overflow drain nozzle on the roof allowed

gasoline to flow onto TK38 roof when the tank was being filled with a finished gasoline blend.

Recommendations:

Tank Roof Drain Lines

Short Term Actions

1. Formalize RP&S Operational Practice of driving through tank farm during heavy rains to verify roof drains are flowing freely and checking the roofs of those tanks that do not appear to be flowing as much. – COMPLETE

2. During monthly tank comparison gauging, have RP&S Operator visually inspect tank roofs for debris or signs or accumulation of liquid. – COMPLETE

3. Add the following items to the PEI Tank Seal Inspection Checklist for yearly inspections:
    a. Tank roof and roof drain sump are free of debris/dirt/slime/algae
    b. Roof drain check valve moves freely and is functioning properly
    c. Roof drain sump has a screen or other device (perforated plate) to stop debris from entering and obstructing the drain system and it is in good condition (this is per API Standard 650).
    d. Roof has/does not have an emergency overflow drain nozzle
    e. Create an SAP notification for any deficiencies found.

    Responsible Person: Dave Theusen
    Due: 9/30/2011

Medium Term Actions

1. Create a maintenance PM work order to do yearly preventative maintenance of all external floating roof tanks just prior to the October rainy season. PM would include removal of all debris from the deck, cleaning out the roof drain sump, and verifying the roof drain check valve is operating freely. This is felt to be more effective than PEI inspections during annual seal inspections because:
    a. PM would occur just prior to the rainy season rather that scattered throughout the year.
    b. If PEI inspection revealed an issue, a maintenance ticket would have to be written to resolve it anyway.

    Responsible Person: Rick Pina
    Due: 9/1/2011

Tank Roof Emergency Overflow Drain Nozzles

Short Term Actions

1. Conduct a risk analysis to determine if roof emergency overflow drains can be removed from single deck floating roof tanks. Review should involve technical resources such as a tank engineer (e.g. from TANCO) or Shell P&T tank expert.

   Responsible Person: Patty Blakeway
   Due: 4/1/2012

   If the risk analysis concludes that emergency overflow drains are not required or recommended on single deck floating roof tanks, consider blinding/capping them off or plugging them with a plumbers plug and also creating a CAIR to remove them and install a lap patch as the tanks come out of service for turnaround.

Check Mate Hydrocarbon Sensing Valves (not causal)

Although it was not a contributing factor to this incident, the TK38 Check Mate Hydrocarbon Sensing Valve was in poor condition. The styrofoam hydrocarbon sensing element was encased in green algae that may have been impenetrable to gasoline. Thus, the Check Mate Valve may have failed to close had there been a leak in the TK38 internal Pivot Master drain system.

Medium Term Actions

1. Create a maintenance PM work order to do yearly preventative maintenance of all Check Mate Hydrocarbon Sensing Valves as recommended by manufacturer. PM would include replacement of the hydrocarbon sensing element as well as cleaning and inspection of the actuator mechanism and check valve internals. – COMPLETE